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Demonstrator's Name: Christopher Godwin

PLEASE NOTE:If ANY of the above information is UNCLEAR or not provided, your grade will NOT be recorded!!

Lab Day (T/W/Th/F):Tuesday

Lab Week (even/odd):odd

Lab time (10:00, 2:30, 6:30):2.30

Laboratory Report Form

Experiment 2.

Equilibria

Checklist:

- **Raw Data Sheet written in pen, signed by TA and attached**
- **Completed Report Form attached**

Student's Initials :OAI

Table 1. Observations and Discussion

$$[Cu(H_2O)_4]^{2+}\,(aq) + 4\,NH_3\,(aq) \approx [Cu(NH_3)_4]^{2+}\,(aq) + 4\,H_2O\,(l)$$

Initial Observations

- Cuso4-light blue colour, faint smell odour
- NH3-Transparent colour, very strong odour.
- HCL-transparent colour and faint smell odour.

Final Observations

- Adding 10 drops of NH3 to the solution of 20 drops Cuso4 turns the solution dark blue in colour and also has a very strong odour.
- Adding 10 drops of HCL into the same solution turns it blue purple with a faintly strong smell
- Adding NH3 back to the same solution turns it dark blue back with a faintly strong smell, a dark blue colour was formed at the meniscus.
- Adding HCL back to the same solution turned it blue purple back with a faint smell, also a dark blue colour was formed at the meniscus.

Discussion

- For the first step, adding NH3 to Cuso4 causes a displacement between the Cu and NH3, thus changing the colour from light blue to dark blue and shifting the equilibrium to the right to consume the excess NH3 ion added in the solution.
- Adding HCL to the same solution causes the equilibrium to shift back to the original position to consume the excess H^+ ion formed, thus forming $Cu(NH3)4^{2+}$
- As we repeated step 2-3 , the equilibrium is moving from left to right when NH3 is added and moves from right to left when HCL is added to consume the excess HCL and NH3 ions of each respective reactions. The reaction can also be explained using the leChatelier's principle which states a reaction will always move in the direction that minimizes the effect of any change involved in a system at equilibruim.

$$2AgNO_3\,(aq) + Na_2CO_3\,(aq) \approx Ag_2CO_3\,(s) + 2\,NaNO_3\,(aq)$$

Initial Observations

- Na2CO3-Transparent colour with no smell
- AgNo3-Transparent colour with no smell

Final Observations

- Adding AgNO3 to 0.1 Mol/l of Na2CO3 causes a change in appearance from a transparent colour to a dark-yellowish colour with a faint smell and also formation of particles at the top of the solution

Discussion

- In the first reaction, there is a precipitate formed due to the double displacement between $AgNO_3$ and Na_2CO_3 thus, causing the reaction to reach equilibrium and shifting it to the right .

Intial Observation (Adding HNO_3 to the same solution)

- HNO_3-a Transparent liquid, with no smell

Final Observation

- Adding HNO_3 to the solution causes a change in appearance from dark yellowish brown to a transparent solution with no precipitate formed(particles disappeared)

Discussion

- When HNO_3 is added to the same solution, there is infact a increase in the numer of H^+ ion in the solution, it is increases the number of CO_3^+ produced thus shifting the equilibrium to the right.

Intial Observation (Adding HCL to the same solution when clear)

- HCL- transparent with no smell

Final Observation

- Adding HCL to the clear solution turns the solution milky and also having a faint smell.

Discussion

- The equilibrium will shift to the right because of the addition of a strong acid to the solution thus adding to the Ag and CO_3 ions present in the solution.

Intial Observation(Adding NH_3 to the same solution)

- NH_3-transparent and very strong smell

Final Observation

- Adding NH_3 to the solution turns it back to a transparent solution with a very strong smell.

Discussion

- NH_3 will mix with the solution and dissolve AgCL which will then form $Ag(NH_3)_2$ ions. So equilibrium will favour the forward reaction due to the Ag and NH_3 ions present in the solution.

Intial Observations (Adding HNO_3 and NH_3 again to the same solution)

- HNO_3-a transparent liquid with no smell.
- NH_3- a transparent liquid with a strong smell

Final Observations

- Adding HNO_3 to the solution turns it back milky with a faint smell and gas was released and the solution became hot.
- After, Adding NH_3 back to the same solution turns it back to a clear solution with a strong odour and gas was released.

Discussion

- After adding HNO_3 to the solution, it heated up and a gas was formed, then adding NH_3 to the solution allowed the HCL present to dissociate with the AgCL and thus the H^+ ion left mixed with NH_3 and converted it to NH_4^+

Intial Observation(adding KI to the same solution)

- KI-a transparent and colourless liquid with no smell

Final Observation

- Adding KI to the solution turns its colour milky with a faint odour.

Discussion

- Adding KI to the reaction would affect the equlibruim change because KI is not compatible with the reaction and thus has no effect on its equilibrium.

Initial Observation(Adding Na2S to the same solution)

- Na2S -A clear solution with a strong bad odour.

Final Observation

- Adding Na2S to the solution turns it non -transparent brown with a strong pungent smell. A precipitate was formed.

Discussion

A precipitate was formed because Na2S is not very soluble in water and thus it does not dissociate completely in water and does not affect the equilibrium shift for this reaction.

$$2\,H^{+}\,(aq) + CO_3^{2-}\,(aq) \approx H_2CO_3\,(aq) \approx H_2O\,(l) + CO_2\,(g)$$

$$Ag^{+}\,(aq) + Cl^{-}\,(aq) \approx AgCl\,(s)$$

$$Ag^{+}\,(aq) + 2NH_3\,(aq) \approx [Ag(NH_3)_2]^{+}\,(aq)$$

$H^+ (aq) + NH_3 (aq) \approx NH_4^+ (aq)$
$Ag^+ (aq) + I^- (aq) \approx AgI (s)$
$2Ag^+ (aq) + S^{2-} (aq) \approx Ag_2S (s)$
$CH_3COOH (aq) + H_2O (l) \approx H_3O^+ (aq) + CH_3COO^- (aq)$ ***Intial Observations*** • CH3COOH-transparent colour and a faint smell. • Universal indicator-red in colour with a faint sweet smell. • NaCH3COO-transparent colour and with no smell • NaOH-transparent colour with faint smell

Final Observation

Buffer

- Adding the universal indicator to two wells containing CH3COOH turns the solution red with a faint strong smell and the pH recorded was a value of 3 that was a medium orange colour
- Adding NaCH3COO to the both wells containing the same solution of the universal indicator and CH3COOH caused a change in colour to a light-orange colour with a pH value of 4
- HCL was then added to the first well in which the pH value became approximately 2 (a dark orange colour)
- NaOH was then added to the second well in which the pH was 7 (light green colour)

Distilled water

- Adding the universal indicator to the two wells containing the distilled water which the pH was 3 (medium orange colour)
- Adding 5 drops HCL to the one of well containing the distilled water and the pH was approximately 4 (a light orange colour)
- Adding 5 drops NaOH to the other well, the pH value was a 9(dark green colour)

Discussion

- Addition of HCL to the well of H2O and CH3COOH increases the H+ ion on the product side thus, shifting the equilibrium to the left to consume the excess H+ ion and also increases the concentration of H2O AND CH3COOH.
- Addition of NaOH to the other well of H2O and CH3COOH increases the number of OH- ion .thus, shifting the equilibrium from the reactants side to the products side in order to consume the excess OH- ions.

$$4Cl^{-}(aq) + [Co(H_2O)_6]^{2+}(aq) \approx [CoCl_4]^{2-}(aq) + 6\,H_2O(l)$$

Initial Observations

- Cocl2- red wine colour with a normal smell
- 12M HCL- transparent colour with a very strong odour

Final Observations

- Adding 12M HCL to a Cocl2 solution turns its colour to blue with a very strong smell.
- Adding H2O to the same solution turns it pink with a faint smell.

Discussion

- Adding HCL to the solution caused a change in colour to blue because of the CL- ion that is in contact with the $Co2^{2+}$ due to the common ion effect which ionizes HCL and then produces (CoCL4)2+.
- As water is added to the equation, it will shift to the left side of the reaction because of the H2O present in the right side of the reaction.

Intial Observation(CuBr2 + H2O)

- CuBr2-Ash in colour with a faint smell.

Final Observation

- Adding water to a CuBr2 solution turns it green in colour with a faint smell.

Discussion

Adding water to the reaction causes a shift in equilibrium to the left as water is a product in the reaction.

$$4\ Br^-(aq) + [Cu(H_2O)_4]^{2+}(aq) \approx [CuBr_4]^{2-}(aq) + 4\ H_2O(l)$$

Initial Observation

- KBr- light pink in colour and has a faintly strong smell.

Final Observation

- Adding CuBr2+H2O to KBr causes a change in colour to blueish green due to heating up in a test tube.

Discussion

- After adding KBr to the solution, there is most likely to be enough bromine to cover the colour of the decomposing bromine ion
- When heating of the solution is finished H2O molecules would leave the solution to form steam.

Intial Observation(CoCL2+12M HCL +H2O+temperature effect)

- Cocl2- red wine colour

Final Observation

- It turns transparent when exposed to heat and has a faint smell.

Discussion

- The CoCl2 is an endothermic reaction so it would favour the right side of the reaction, but under normal condition it would favour the left side of the reaction.

Calculations:

Find the Difference in pH of H2O+ Buffer after the addition of strong base and acid

1. pH of H2O-7.0
2. pH of Buffer-
   $CH3COOH_{(aq)}+H2O_{(g)} \rightleftharpoons CH3COO^-_{(aq)}+H3O^+_{(aq)}$
- Drops: 10 dr/g(0.1mol/l) for CH3COOH
- Drops: 10 dr/g(0.1mol/l) for CH3COO

(CH3COOH): (0.1 mol/l)(10dr/g / 20dr/g)=0.05mol/l

(CH3COO): (0.1mol/l)(10dr/g / 20 dr/g)=0.05mol/l

Henderson-Hasselbalch (acid form)

$PH=pKa +Log(A^-/HA)$

Where (HA)=acid concentration

(A^-)=conjugate base

$Ka(CH3COOH)=1.8 *10^{-5}$

$PH=-log(H^+)$

$POH=-log(OH^-)$

pKa=-log Ka

$PH=(1.8*10^{-5})+log(0.05/0.05)mol/l$

PH=4.74.

3. PH of H2O +HCL:
   $(HCL)_{intial}$=0.1mol/l , V_{intial}=5 dr/g
   V_{H2O}=20 dr/g, V_{final}=25dr/g
   From the equation we know $C_iV_i=C_FV_F$
   $C_F=(C_iV_i)/ V_F$
   C_F=(0.1mol/l)(5dr/g)/(25dr/g)
   C_F=0.02mol/l
   $C_F=(HCL)_F=(H^+)$
   $PH =-log(H^+)$
   PH=-log(0.02)
   PH=1.70
4. PH of H20 +NAOH:
   $(NAOH)_F=(OH^-)$
   PH+POH=14.00
   POH=14.00-1.70
   POH=12.3
5. PH of Buffer + HCL (CH3COOH/CH3COO)
   $CH3COO^- +HCL \longrightarrow CH3COOH + CL^-$
   V_f= 25dr/g
   $V(CH3COO^-)$=10 dr/g (0.10 mol/l)
   V (HCL)=5 dr/g(0.10mol/l)
   V(CH3COOH)=10 dr/g(0.10mol/l)
   (CH3COO-)=(0.10mol/l)(10/25 dr/g)
   (CH3COO-)=0.04mol/l
   (HCL)=(0.10mol/l)(5/25 dr/g)
   (HCL)=0.02mol/l
   (CH3COOH)=(0.10mol/l)(10/25 dr/g)
   (CH3COOH)=0.04mol/l

	CH_3COO^- + HCL ⟶ CH_3COOH + CL^-		
Initial concentration(mol/l)	0.04	0.02	0.04
Change in concentration(mol/l)	-0.02	-0.02	+0.02
Equilibrium	0.02	-	0.06

PH=pKa +log(A^- /HA)
PH=4.74+log(0.02/0.06 mol/l)
PH=4.74-0.48
PH=4.26
Change in Buffer + HCL
PH=PH final- PH intial
PH= 4.26-4.74
PH=-0.48

6. PH of Buffer + NAOH(CH_3COOH/CH_3COO^-)
   $CH_3COOH + NAOH \longrightarrow CH_3COO^- + H_2O$
   V_f=25 dr/g
   V(CH_3COOH)=10 dr/g(0.10mol/l)
   V(NAOH)=5dr/g(0.10mol/l)
   V(CH_3COO^-)=10dr/g(0.10mol/l)
   (CH_3COOH)=(0.10mol/l)(10/25)dr/g
   (CH_3COOH)=0.04mol/l
   (NAOH)=(0.10mol/l)(5/25)dr/g
   (NAOH)=0.02 mol/l
   (CH_3COO)=0.04mol/l

	$CH_3COOH + NAOH \longrightarrow CH_3COO + H_2O$		
Initial Concentrations(mol/l)	0.04	0.02	0.04
Change in Concentration(mol/l)	-0.02	-0.02	+0.02
Equilibrium	0.02	-	0.06

PH=pKa+log(OH/H)
PH= 4.74+log(0.06/0.02)
PH=4.74+0.48
PH=5.22
Change in PH for buffer + base
PH=PH final -PH initial
PH=5.22-4.74
PH=0.48

Additional Discussion (if desired….otherwise, discussion can be combined with the observations in the table):

Conclusion:

There are various ways to determine the equilibrium on a reaction and the lab experiment conducted shows us some different examples on how different effects can change the equilibrium of a system either favouring the products or the reagents side of the reaction. In this lab we analysed how addition of strong acid

and bases such as HCL and NAOH can affect the equilibrium of a system, also the addition of temperature to a reaction would mostly favour the product side of such reaction because increase in temperature would lead to an increase in the product. Precipitate formed can also cause a change in equilibrium to one side either product or reactants because it would want to consume the excess products or reactants formed. Common ion effect would also affect the equilibrium of a reaction because it would produce an ion that is in the reaction such as NH_3 to NH_4^+ which will continue to increase its concentration and then forming a solution.

Buffer effects were also proved in this lab experiment such as:

Adding water to acid(HCL) changed its PH to 4(light orange)

Adding water to base (NAOH)changed its PH to 9(dark green)

Adding buffer to acid (HCL) changed its PH to 2(orange)

Adding buffer to base (NAOH) changed its PH to 7(light green)

Thus, showing that buffer and water can also affect the PH of a reaction and colour changes were also observed.